Chapter 710 Traffic Barriers

710.01 General

Traffic barriers are used to reduce the severity of accidents that occur when an errant vehicle leaves the traveled way. However, traffic barriers are obstacles that the vehicle will encounter and must only be used when justified by accident history or the criteria in Chapter 700.

710.02 References

Roadside Design Guide, AASHTO

Bridge Design Manual, M 23-50, WSDOT

Standard Plans for Road, Bridge, and Municipal Construction (Standard Plans), M 21-01, WSDOT

Traffic Manual, M 51-02, WSDOT

710.03 Definitions

barrier terminal A crashworthy end treatment for longitudinal barriers that is designed to reduce the potential for spearing, vaulting, rolling, or excessive deceleration of impacting vehicles from either direction of travel. Beam guardrail terminals include anchorage.

controlled releasing terminal (CRT) post A standard length guardrail post that has two holes drilled through it so that it will break away when struck.

crashworthy A feature that has been proven acceptable for use under specified conditions either through crash testing or in-service performance.

guardrail transition A section of barrier used to produce a gradual stiffening of a flexible or semirigid barrier as it connects to a more rigid barrier or fixed object.

impact attenuator system A device that acts primarily to bring an errant vehicle to a stop at a deceleration rate tolerable to the vehicle occupants or to redirect the vehicle away from a hazard.

length of need The length of a traffic barrier needed to shield a hazard.

longitudinal barrier Traffic barrier oriented parallel or nearly parallel to the roadway. The purpose is to contain or redirect errant vehicles. Beam guardrail, cable barrier, bridge rail, and concrete barrier are longitudinal barriers. Longitudinal barriers are categorized as rigid, unrestrained rigid, semirigid, and flexible. They can be installed as roadside or median barriers.

shy distance The distance from the edge of the traveled way beyond which a roadside object will not be perceived as an immediate hazard by the typical driver to the extent that the driver will change the vehicle's placement or speed.

traffic barrier A longitudinal barrier, including bridge rail, or an impact attenuator used to redirect vehicles from hazards located within an established Design Clear Zone, to prevent median crossovers, to prevent errant vehicles from going over the side of a bridge structure, or (occasionally) to protect workers, pedestrians, or bicyclists from vehicular traffic.

710.04 Project Requirements

This section identifies the barrier elements that must be addressed according to the Design Matrices in Chapter 325. Remove any barrier that is not needed (based on the criteria in Chapter 700) <u>or</u> poses a more severe hazard than the hazard it is shielding.

(1) Barrier Terminals and Transitions

(a) **Basic Design Level (B).** When the basic design level (B) is indicated in the Terminal and Transition Section column of a Design Matrix, install, replace, or upgrade transitions as discussed in 710.06(3), Transitions and Connections.

Impact attenuators must meet the requirements found in Chapter 720, Impact Attenuators.

When installing new terminals, consider extending the guardrail to meet the length of need criteria in 710.05(4) as a spot safety enhancement.

Concrete barrier terminals must meet the requirements found in 710.08(2). When the end of a concrete barrier has been terminated with a small mound of earth (a design formerly known as a Concrete Barrier Berm), remove and replace with a crashworthy terminal, except as noted in 710.09.

Redirectional land forms, also referred to as earth berms, were installed to mitigate hazards located in depressed medians and at roadsides. They were constructed of materials that provided support for a traversing vehicle. With slopes in the range of 2H:1V to 3H:1V, they were intended to redirect errant vehicles. The use of redirectional land forms has been discontinued as a means for mitigating fixed objects. Where redirectional land forms currently exist as mitigation for a fixed object, ensure that the hazard they were intended to mitigate is removed, relocated, made crashworthy, or shielded with barrier. Landforms may be used to provide a smooth surface at the base of a rock cut slope.

Replace guardrail terminals that do not have a crashworthy design with crashworthy guardrail terminals. See 710.06(2), Terminals and Anchors. Common features of noncrashworthy designs:

- No cable anchor.
- A cable anchored into concrete in front of the first post.
- Second post not breakaway (CRT).
- Design A end section. (Design C end sections may be left in place.)
- Beam guardrail on both sides of the posts (two sided).
- Buried guardrail terminals that slope down such that the guardrail height is reduced to less than 24 in.

One terminal that was used extensively on Washington's highways was the Breakaway Cable Terminal (BCT). This system used a parabolic flare similar to the SRT and Type 1 anchor. Type 1 anchor posts are wood set in a steel tube or a concrete foundation.

BCTs that have at least a 3 ft offset may remain in place when the basic design level applies unless the guardrail run or anchor is being reconstructed or reset. (Raising the rail element is not considered reconstruction or resetting.) Replace all BCTs that have less than a 3 ft offset.

Existing transitions that do not have a curb but are otherwise consistent with the designs shown in the Standard Plans may remain in place.

For preservation projects, terminal and transition work may be programmed under a separate project as described in Chapter 410.

(b) **Full Design Level (F).** When the full design level (F) is indicated, the requirements for the basic design level apply except that all BCTs and concrete barrier berms must be replaced.

(2) Standard Run of Barrier

In Chapter 325, the matrices have Design Elements "Standard Run" under Barriers. A "Standard Run" of barrier consists of longitudinal barrier that can be found in the Standard Plans manual.

(a) **Basic Design Level (B).** When the basic design level (B) is indicated in the Standard Run column of a Design Matrix and the height of W-beam guardrail is or would be reduced to less than 24 in from the ground to the top of the rail element, adjust the height to that shown in the Standard Plans. If Type 1 Alternate W-beam guardrail is present, raise the rail element after each overlay.

Overlays in front of safety shaped concrete barriers can extend to the top of the lower, near-vertical face of the barrier before adjustment is required. Allow no more than 13 in from the pavement to beginning of the top near-vertical face on either the F or NJ shape barriers. Allow no less than 32 inches from the pavement to the top of the single slope barrier. Allow no less than 27 in from the ground to the top cable of the Type 1 cable barrier and no less than 30 in for the Type 2 and Type 3 cable barrier.

(b) **Full Design Level (F).** When the full design level (F) is indicated, in addition to the requirements for the basic design level, the barrier must meet the requirements found in the following:

700.06	Median Barrier Guidelines
710.05(1)	Shy Distance
710.05(2)	Barrier Deflections
710.05(3)	Flare Rate
710.05(4)	Length of Need
710.05(5)	Median Barrier Selection
710.06	Beam Guardrail
710.07	Cable Barrier
710.08	Concrete Barrier

Examples of barriers that are not acceptable as a “standard run” are:

- W-beam guardrail with 12 ft-6 in post spacing and no blockouts.
- W-beam guardrail on concrete posts.
- Cable barrier on wood or concrete posts.
- Half-moon or C shape rail elements.

(3) Bridge Rail

When the Bridge Rail column of a matrix applies to the project, the bridge rails must meet the following requirements:

Use an approved, crash tested concrete bridge rail on new bridges or bridges to be widened. The *Bridge Design Manual* provides examples of typical bridge rails. Consult the Bridge and Structures Office regarding bridge rail selection and design and for design of the connection to an existing bridge.

An existing bridge rail on a highway with a posted speed of 30 mph or less may remain in place if it is not located on a bridge over a National Highway System (NHS) highway. <u>When Type 7 bridge rail is present on a bridge over a NHS highway with a posted speed of 30 mph or less</u> it may remain place, regardless of the type of metal rail installed. All other bridge rails must be evaluated for strength and geometrics. See 710.11 for guidance on retrofit techniques. The funding source for retrofit of existing bridge rail is dependent on the length of the structure. Bridge rail retrofit, for bridges less than 250 ft in length (or a total bridge rail length of 500 ft), is funded by the project (Preservation or Improvement). For longer bridges, the retrofit can be funded by the I2 subprogram. Contact programming personnel to determine if funding is available.

The Type 7 bridge rail is common. Type 7 bridge rails have a curb, a vertical-face parapet, and an aluminum top rail. The curb width and the type of aluminum top rail dictate the adequacy of the Type 7 bridge rail as shown on Figure 710-1. Consult the Bridge and Structures Office for assistance in evaluating other bridge rails.

710.05 Barrier Design

When selecting a barrier, consider the flexibility, cost, and maintainability of the system. It is generally desirable to use the most flexible system possible to minimize damage to the impacting vehicle and injury to the vehicle’s occupant(s). However, since nonrigid systems sustain more damage during an impact, the exposure of maintenance crews to traffic might be increased.

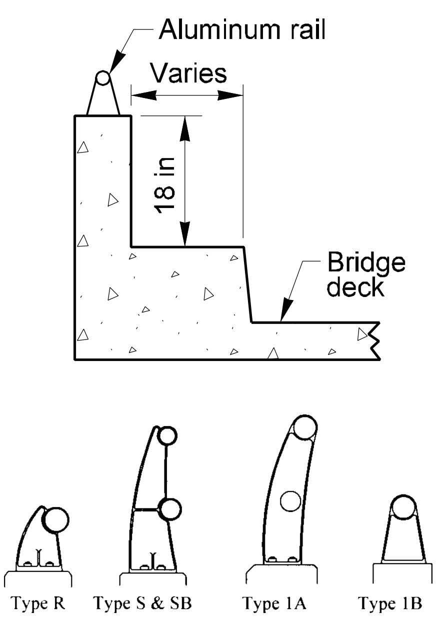
Concrete barrier maintenance costs are lower than for other barrier types. Deterioration due to weather and vehicle impacts is limited. Unanchored precast concrete barrier can usually be realigned or repaired when moved from its alignment. However, heavy equipment may be required to reposition or replace barrier segments. Therefore, in medians, consider the shoulder width and the traffic volume when determining the acceptability of unanchored precast concrete barrier versus a rigid concrete barrier.

Drainage, alignment, and drifting snow or sand are considerations that can influence the selection of barrier type. Beam guardrail and concrete barrier can contribute to snow drifts. Consider long-term maintenance costs associated with snow removal at locations prone to snow drifting. Slope flattening is highly recommended, even at additional cost, to eliminate the need for the barrier. Cable barrier is not an obstruction to drifting snow and can be used if slope flattening is not practical.

When designing a barrier for use on a Scenic Byway or Heritage Tour Route (formerly Scenic and Recreational Highway), consider barriers that are consistent with the recommendations in the associated Corridor Management Plan (if one is available). Contact the region's Landscape Architect or the Headquarters' Heritage Corridors Program manager to determine if the project is on such a designated route. Low cost options, such as using weathering steel beam guardrail (710.06) or cable barrier (710.07) might be feasible on many projects. Higher cost options, such as steel backed timber rail and stone guardwalls (710.09) might require a partnering effort to fund the additional costs. Grants might be available for this purpose if the need is identified early in the project definition phase. (See Chapter 120.)

(1) Shy Distance

Provide 2 ft of additional widening for shy distance when a barrier is to be installed in areas where the roadway is to be widened and the shoulder width will be less than 8 ft. This shy distance is not required when the section of roadway is not being widened or the shoulders are at least 8 ft wide.



	Curb Width	
Aluminum Rail Type	9 in or less	Greater than 9 in*
Type R, S, or SB	Bridge rail adequate	Bridge rail adequate
Type 1B or 1A	Bridge rail adequate	Upgrade bridge rail
Other	Consult the Bridge and Structures Office	

* When the curb width is greater than 9 in, the aluminum rail must be able to withstand a 5 kip load.

Type 7 Bridge Rail Upgrade Criteria
Figure 710-1

(2) Barrier Deflections

All barriers except rigid barriers (concrete bridge rails for example) will deflect when hit by an errant vehicle. The amount of deflection is primarily dependent on the stiffness of the system. Vehicle speed, angle of impact, and weight also affect the amount of barrier deflection. For flexible and semirigid roadside barriers, the deflection distance is designed to prevent the impacting vehicle from striking the object being shielded. For unrestrained rigid systems (unanchored precast concrete barrier), the deflection distance is designed to prevent the barrier from being knocked over the side of a drop-off or steep fill slope (2H:1V or steeper).

In median installations, the deflected system must not become a hazard to oncoming traffic. In addition, narrow medians provide little space for maintenance crews to repair or reposition the barrier. Avoid installing deflecting barriers in medians that provide less than 8 ft from the edge of the traveled way to the face of the barrier.

Use a rigid system where deflection cannot be tolerated such as in narrow medians or at the edge of a bridge deck (vertical drop-off). Runs of rigid concrete barrier can be cast-in-place, extruded with appropriate footings, or, for precast concrete barrier, bolted or bracketed to the underlying material.

See Figure 710-2 for barrier deflection design values to be used when selecting a longitudinal barrier. The deflection distances for cable and beam guardrail are the minimum measurements from the face of the barrier to the hazard. The deflection distance for unanchored concrete barrier is the minimum measurement from the back edge of the barrier to the drop-off or slope break.

Barrier Type	System Type	Deflection
Cable barrier or beam guardrail on G-2 posts	Flexible	up to 12 ft (face of barrier to object)
Beam guardrail Types 1, 1a, 2, and 10	Semirigid	3 ft (face of barrier to object)
Two-sided W-beam guardrail Types 3 and 4	Semirigid	2 ft (face of barrier to object)
Permanent concrete barrier, unanchored	Unrestrained Rigid	3 ft (1) (back of barrier to object)
Temporary concrete barrier, unanchored	Unrestrained Rigid	2 ft (2) (back of barrier to object)
Concrete barrier, anchored	Rigid	no deflection

(1) When placed in front of a 2H:1V or flatter fill slope, the deflection distance can be reduced to 2 ft.

(2) When used as temporary bridge rail, anchor all barrier that is within 3 ft of a drop-off.

Longitudinal Barrier Deflection
Figure 710-2

(3) Flare Rate

Flare the ends of longitudinal barriers where possible. There are four functions of the flare:

- To locate the barrier and its terminal as far from the traveled way as is feasible.
- To reduce the length of need.
- To redirect an errant vehicle without serious injuries to its occupants.
- To minimize a driver's reaction to the introduction of an object near the traveled way.

Keeping flare rates as flat as practical preserves the barrier's redirectional performance and minimizes the angle of impact. But, it has been shown that an object (or barrier) close to the traveled way might cause a driver to shift laterally, slow down, or both. The flare reduces this reaction by gradually introducing the barrier so that the driver does not perceive the barrier as a hazard. The flare rates in Figure 710-3 satisfy all four functions listed above. More gradual flares may be used.

Posted Speed mph	Rigid System	Unrestrained Rigid System	Semirigid System
70	20:1	18:1	15:1
60	18:1	16:1	14:1
55	16:1	14:1	12:1
50	14:1	12:1	11:1
45	12:1	11:1	10:1
40 or below	11:1	10:1	9:1

Longitudinal Barrier Flare Rates
Figure 710-3

(4) Length of Need

The length of traffic barrier required to shield a hazard (length of need) is dependent on the location and geometrics of the hazard, direction(s) of traffic, posted speed, traffic volume, and type and location of traffic barrier. When designing a barrier for a fill slope as recommended in Chapter 700, the length of need begins at the point where barrier is recommended. For fixed objects and water hazards, Figures 710-11a and b show design parameters for determining the necessary length of a barrier for both adjacent and opposing traffic on relatively straight sections of highway. When the barrier is to be installed on the outside of a horizontal curve, the length of need can be determined graphically as shown on Figure 710-11c. For installations on the inside of a curve, determine the length of need as though it was straight. Consider the flare rate, barrier deflection, and barrier end treatment to be used when determining the length of need.

Before the actual length of need is determined, establish the lateral distance between the proposed barrier installation and the item shielded. This distance must be greater than or equal to the anticipated deflection of the longitudinal barrier. (See Figure 710-2 for barrier deflections.) Place the barrier as far from the edge of the traveled way as possible while maintaining the deflection distance.

If the end of the length of need is near an adequate cut slope, extend the barrier and embed it in the slope. (See 710.06(2)(a).) Avoid gaps of 300 ft or less. Short gaps are acceptable when the barriers are terminated in a cut slope. If the end of the length of need is near the end of an existing barrier, it is recommended that the barriers be connected to form a continuous barrier. Consider maintenance access when determining whether to connect barriers.

(5) Median Barrier Selection and Placement Considerations

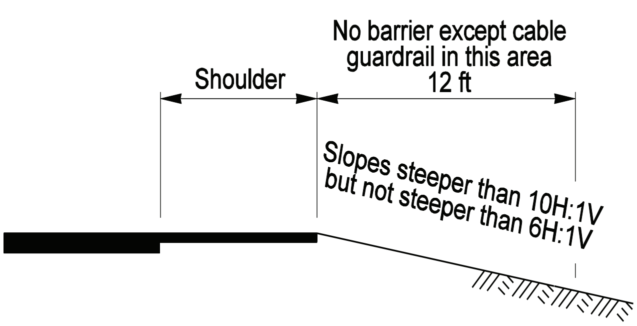
As with all barriers, the most desirable installation uses a system that is the most flexible system appropriate for the location and is placed as far from the traveled way as practical. With median barriers, the deflection characteristics and placement of the barrier for a traveled way in one direction can have an impact on the traveled way in the opposing direction. In addition, the median slopes and environmental issues might influence the type of barrier that is appropriate.

In narrow medians, the deflected system must not become a hazard to oncoming traffic. In addition, narrow medians provide little space for maintenance crews to repair or reposition the barrier. Avoid installing deflecting barriers in medians that provide less than 8 ft from the edge of the traveled way to the face of the barrier. In wider medians, the selection of barrier might depend on the slopes in the median.

At locations where the median slopes are relatively flat (10H:1V or flatter), unrestrained precast concrete barrier, beam guardrail, and cable barrier can be used depending on the available deflection distance. At these locations, position the barrier as close to the center as possible so that the recovery distance can be maximized for both directions. It might be necessary to offset the barrier from the flow line to avoid impacts to the drainage flow. Cable barrier is preferred with medians that are 30 ft or wider. For medians wider than 30 ft, provide justification for placing a barrier closer than 15 ft from the edge of a traveled way.

In wide medians where the slopes are steeper than 10H:1V but not steeper than 6H:1V, cable barrier placed near the center of the median is preferred. Placement of beam guardrail requires that the barrier be placed at least 12 ft from the slope break as is shown on Figure 710-4. Do not use concrete barrier at locations where the foreslope into the face of the barrier is steeper than 10H:1V.

At locations where the roadways are on independent alignments and there is a difference in elevation between the roadways, the slope from the upper roadway might be steeper than 6H:1V. In these locations, position the median barrier along the upper roadway and provide deflection and offset distance as discussed previously. Barrier is generally not necessary along the lower roadway except where there are fixed objects in the median.



Guardrail Locations on Slopes
Figure 710-4

710.06 Beam Guardrail

(1) Beam Guardrails

Beam guardrail systems are shown in the Standard Plans.

Strong post W-beam guardrail (Types 1 through 4) and thrie beam guardrail (Types 10 and 11) are semirigid barriers used predominately on roadsides. They also have limited application as median barrier. Installed incorrectly, strong post beam guardrail can cause vehicle snagging or spearing. This can be avoided by lapping the rail splices in the direction of traffic as shown in the Standard Plans, by using crashworthy end treatments, and by blocking the rail away from the strong posts. Do not use more than two 8 in blockouts.

On asphalt concrete pavements (where overlays are anticipated), the Type 1 Alternate guardrail can be used to allow raising of the guardrail without having to adjust the posts.

Weak post W-beam guardrail (Type 20) and thrie beam guardrail (Type 21) are flexible barrier systems that can be used where there is adequate deflection distance. These systems use weak steel posts. The primary purpose of these posts is to position the guardrail vertically and they are designed to bend over when struck. These more flexible systems will result in less damage to the impacting vehicle. Since the weak posts will not result in snagging, blockouts are not necessary.

Keep the slope of the area between the edge of shoulder and the face of the guardrail as flat as possible. The preferred slope is 10H:1V or flatter. Do not place beam guardrail on a fill slope steeper than 6H:1V. On fill slopes between 6H:1V and 10H:1V, beam guardrail must not be placed within 12 ft of the break point. (See Figure 710-4.)

On the high side of superelevated sections, place beam guardrail at the edge of shoulder.

Generally, 2 ft of shoulder widening behind the barrier is provided from the back of the post to the beginning of a fill slope. If the slope is 2H:1V or flatter, this distance can be measured from the face of the guardrail rather than the back of the post. (See Figure 710-12, Case 1.)

On projects where no roadway widening is proposed and the minimum 2 ft shoulder widening behind the barrier is not practical, long post installations are available as shown on Figure 710-12, Cases 3, 4, 5, and 6. When guardrail is to be installed in areas where the roadway is to be widened, the use of Cases 4, 5, or 6 requires a design deviation.

Rail washers on beam guardrail are not normally used. If rail washers are present, they are not required to be removed. However, if the rail element is removed for any reason, do not reinstall the rail washers. In areas where heavy snow accumulations are expected to cause the bolts to pull out, specify snow load post and rail washers in the contract documents. (Snow load post washers are used to prevent the bolts from pulling through the posts and snow load rail washers are used to prevent the bolt head from pulling through the rail.) Rail washers are never to be used within the limits of a guardrail terminal except at the end post where they are required for anchorage of the rail.

It is preferred that no curbs be installed in conjunction with beam guardrail. However, if a curb is necessary, the 3 in high curb is preferred. The 4 in high curb can only be used at locations where the 3 in curb will not be adequate. In new installations, do not use 6 in high curb in conjunction with beam guardrails. Existing 6 in high curb is allowed to remain in place. If work requires replacement of an existing 6 in curb, it must be replaced with a 3 in or 4 in curb, whichever is appropriate.

The preferred location of a curb, when used in conjunction with beam guardrail, is behind the face of the beam as shown in the Standard Plans.

Beam guardrail is usually galvanized and has a silver color. It can also be provided in a weathering steel that has a brown or rust color. Weathering steel guardrail might be desirable on Scenic Byways or Heritage Tour Routes. (See 710.05.)

(2) Terminals and Anchors

A guardrail anchor is required at the end of a run of guardrail to develop its tensile strength throughout its length. In addition, when the end of the guardrail is subject to head-on impacts, a crashworthy guardrail terminal is required. (See the Standard Plans.)

(a) **Buried Terminals.** The buried terminal (BT) is designed to terminate the guardrail by burying the end in a backslope. The BT is the preferred terminal because it eliminates the exposed end of the guardrail.

The BT uses a Type 2 anchor to develop the tensile strength in the guardrail. The entire BT can be used within the length of need.

The backslope required to install a BT must be 3H:1V or steeper and at least 4 ft in height above the roadway. Flare the guardrail into the backslope using a flare rate that meets the criteria in 710.05(3). Provide a 10H:1V or flatter foreslope into the face of the guardrail (and up to 4H:1V in the ditch section of the Type 2 buried terminal) and maintain the full guardrail height to the foreslope/backslope intersection. This might require filling ditches and installing culverts in front of the guardrail face.

(b) **Flared Terminal.** If a BT cannot be installed as described above, consider a flared terminal. (See Figure 710-13.) There are currently 2 acceptable sole source proprietary designs: the Slotted Rail Terminal (SRT) and the Flared Energy Absorbing Terminal (FLEAT). Both of these designs include an anchor for developing the tensile strength of the guardrail. The length of need begins at the third post for both flared terminals.

1. The SRT uses W-beam guardrail with slots cut into the corrugations and wood breakaway and controlled release terminal (CRT) posts that are designed to break away when hit. The end of the SRT is offset from the tangent guardrail run by the use of a parabolic flare. When struck head on, the first 2 posts are designed to break away and the parabolic flare gives the rail a natural tendency to buckle, minimizing the possibility of the guardrail end entering the vehicle. The buckling is facilitated by the slots in the rail. The CRT posts provide strength to the system for redirection and deceleration without snagging the vehicle.

The SRT has a 4 ft offset of the first post.

2. The FLEAT uses W-beam guardrail with a special end piece that fits over the end of the guardrail and wood breakaway and CRT posts. The end of the FLEAT is offset from the tangent guardrail run by the use of a straight flare. When struck head on, the end piece is forced over the rail, bending the rail and forcing it away from the impacting vehicle.

   The FLEAT is available in 2 designs based on the posted speed of the highway. For high speed highways (posted speed of 45 mph or greater) use a FLEAT 350 that has a 4 ft offset at the first post. For lower speed highways (posted speed of 40 mph or less), use a FLEAT TL-2 that has a 20 in offset at the first post.

When a flared terminal is specified, it is critical that embankment also be specified so that the area around the terminal can be flattened as shown on the Standard Plans. For every foot of height of the embankment, 13 cubic yards of "Embankment in Place" must be specified.

No snow load rail washers are allowed within the limits of these terminals.

The FHWA has granted approval to use these sole source proprietary terminals without justification on a project by project basis.

(c) **Nonflared Terminal.** Where widening to provide the offset for a flared terminal is not practical, consider a nonflared terminal. (See Figure 710-13.) There are currently two acceptable sole source proprietary designs; the ET PLUS and the Sequential Kinking Terminal (SKT). Both of these systems use W-beam guardrail with a special end piece that fits over the end of the guardrail and wood breakaway and CRT posts. When hit head-on, the end piece is forced over the rail and either flattens or bends the rail and then forces the rail away from the impacting vehicle.

Both of these terminals include an anchor for developing the tensile strength of the guardrail. The length of need begins at the third post for both terminals.

Both of these terminals are available in two designs based on the posted speed of the highway. The primary difference in these designs is the length of the terminal. For high speed highways (posted speed of 45 mph or greater), use the ET PLUS TL3 or SKT 350 that are 50 ft long. For lower speed highways (posted speed of 40 mph or less), use the ET PLUS TL2 or SKT-TL2 that are 25 ft long.

While these terminals do not require an offset at the end, a flare is recommended so that the end piece does not protrude into the shoulder. These terminals may have a 12 in offset to the first post. Four feet of widening is required at the end posts to ensure that the system is properly anchored. For every foot of height of embankment, 3 cubic yards of "Embankment in Place" must be specified.

No snow load rail washers are allowed within the limits of these terminals.

The FHWA has granted approval to use these sole source proprietary terminals without justification on a project by project basis.

(d) **Other Anchor Applications.** Use the Type 1 anchor to develop the tensile strength of the guardrail on the end of guardrail runs where a crashworthy terminal is not required. Use the Type 4 anchor to develop the tensile strength of the guardrail on the trailing end of guardrail runs along one-way highways. Use the Type 5 anchor with the Weak Post Intersection Design. (See 710.06(4) Cases 12 and 13.) Use the Type 7 anchor to develop tensile strength in the middle of a guardrail run when the guardrail curves and weak posts are used. (See 710.06(4) cases 9, 12, and 13.)

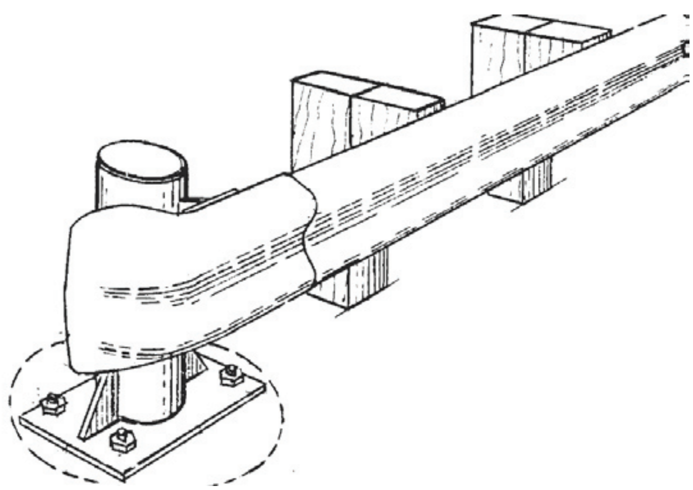
The old Type 3 anchor was primarily used at bridge ends. (See Figure 710-5.) This anchor consisted of a steel pipe mounted vertically in a concrete foundation. Bridge approach guardrail was then mounted on the steel pipe. On one-way highways, these anchors were usually positioned so that neither the anchor nor the bridge rail posed a snagging hazard. In these cases, the anchor may remain in place if a stiffened transition section is provided at the connection to the post. On two-way highways the anchor may present a snagging hazard. In these cases, install a connection from the anchor to the bridge rail if the offset from the bridge rail to the face of the guardrail is 18 in or less. If the offset is greater than 18 in, remove the anchor and install a new transition and connection.

Locations where crossroads and driveways cause gaps in the guardrail require special consideration. Elimination of the need for the barrier is the preferred solution. Otherwise, a barrier flare might be required to provide sight distance. If the slope is 2H:1V or flatter and there are no hazards on or at the bottom of the slope, a terminal can be used to end the rail. Place the anchor of this installation as close as possible to the road approach radius PC. If there is a hazard at or near the bottom of the slope that cannot be mitigated, then the Weak Post Intersection Design (see 710.04(4) and the Standard Plans) can be used. This system can also be used at locations where a crossroad or road approach is near the end of a bridge and installing a bridge approach guardrail placement (including guardrail transition and terminal) is not possible.

(3) Transitions and Connections

When there is an abrupt change from one barrier type to a more rigid barrier type, a vehicle hitting the more flexible barrier is likely to be caught in the deflected barrier pocket and directed into the more rigid barrier. This is commonly referred to as pocketing. A transition stiffens the more flexible barrier by decreasing the post spacing, increasing the post size, and using stiffer beam elements to eliminate the possibility of pocketing.

When connecting beam guardrail to a more rigid barrier or a structure, or when a rigid object is within the deflection distance of the barrier, use the transitions and connections that are shown on Figures 710-6 and 10 and detailed in the Standard Plans. The transition pay item includes the connection.



Old Type 3 Anchor
Figure 710-5

	Connection
Unrestrained concrete barrier	A
Rigid untapered safety shaped bridge rails or barriers (1)	B
Bridge rails with curbs 9 in or less in width	B
Bridge rails with curbs between 9 and 18 in wide	C
Vertical walls or tapered safety shape barrier (1)	D

(1) New safety shaped bridge rails are designed with the toe of the barrier tapered so that it does not project past the face of the approach guardrail.

Guardrail Connections
Figure 710-6

(4) Guardrail Placement Cases

The Standard Plans contain placement cases that show all of the beam guardrail elements required for typical situations. The following is a description of each.

Case 1 is used only where there is one-way traffic. It uses a crashworthy terminal on the approach end and a Type 4 anchor on the trailing end.

Case 2 is used where there is two-way traffic. A crashworthy terminal is used on both ends. When flared terminals are used on both ends, a minimum of 25 ft of guardrail is required between the terminal limits.

Case 3 is used at railroad signal supports on one-way or two-way roadways. A terminal is used on the approach end but usually cannot be used on the trailing end because of its proximity to the railroad tracks. For one-way roadways, a Type 4 anchor is used on the trailing end. On two-way roadways a Type 1 anchor is used on the trailing end. If there is a history of crossover accidents, consider additional protection, such as an impact attenuator.

Case 4 is used where guardrail on the approach to a bridge is to be shifted laterally to connect with the bridge rail. A terminal is used on the approach end and a transition is required at the bridge end. A curve in the guardrail is shown to shift it to the bridge rail. However, the length of the curve is not critical and the only requirement is to provide a smooth curve that is not more abrupt than the allowable flare rate. (See Figure 710-3.)

Case 5 is a typical bridge approach where a terminal and a transition are required.

Case 6 is used on bridge approaches where opposing traffic is separated by a median that is 36 ft or wider. This case is designed so that the end of the guardrail will be outside of the clear zone for the opposing traffic.

Cases 7 and 8 are used with beam guardrail median barrier when median hazards such as bridge piers are encountered. A transition is required on the approach end for each direction and the flare rate must not be more abrupt than the allowable flare rate. (See Figure 710-3.)

Case 9 is used on bridge approaches where opposing traffic is separated by a median less than 36 ft wide. This design, called a "Bull Nose Terminal," treats both bridge ends and the opening between the bridges. The "nose" is designed to collapse when struck head-on and the ribbon strength of the rail brings the vehicle to a controlled stop. Type 7 anchors are installed on each side of the nose to develop the ribbon strength.

Since an impacting vehicle will penetrate into the system, it is critical that no fixed object be located within the first 30 ft of the system.

Case 10 (A, B, and C) is used at roadside hazards (such as bridge piers) when 3 ft or more is available from the face of the guardrail to the hazard. The approach end is the same for one-way or two-way traffic. Case 10A is used with two-way traffic and, therefore, a terminal is required on the trailing end. Case 10B is used for one-way traffic when there is no need to extend guardrail past the bridge pier and a Type 4 anchor is used to end the guardrail. Case 10C is used for one-way traffic when the guardrail will extend for a distance past the bridge pier.

Case 11 (A, B, and C) is used at roadside hazards (such as bridge piers) when the guardrail is to be placed within 3 ft of the hazard. Since there is no room for deflection, the rail in front of the hazard must be considered a rigid system and a transition is necessary. The trailing end cases are the same as described for Placement Case 10.

Cases 12 and 13 are called “Weak Post Intersection Designs.” They are used where an intersection requires a gap in the guardrail or there is not adequate space for a bridge approach installation that includes a transition and/or terminal. These placements are designed to collapse when hit at the nose, and the ribbon strength of the rail brings the vehicle to a stop. A Type 7 anchor is used to develop the ribbon strength. These designs include a Type 5 transition for connection with bridge rail and a Type 5 anchor at the other end of the rail. The Type 5 anchor is not a breakaway anchor and, therefore, can only be used on low speed side roads and driveways.

Since an impacting vehicle will penetrate into the system, it is critical that no fixed object be located within the clear area shown on the standard plan. The 25 ft along the side road is critical for the operation of this system.

These designs were developed for intersections that are approximately perpendicular. Evaluate installation on skewed intersections on a case-by-case basis. Use the Case 22 placement if it is not feasible to install this design according to the standard plan.

Case 14 shows the approach rail layout for a Service Level 1 bridge rail system. Type 20 guardrail is used on the approach and no transition is required between the Type 20 guardrail and the Service Level 1 bridge rail since they are both weak post systems. A Type 6 transition is used when connecting the Type 20 to a strong post guardrail or a terminal.

Case 15 is used to carry guardrail across a box culvert where there is insufficient depth to install standard posts for more than 17.7 ft. This design uses steel posts anchored to the box culvert to support the rail. Newer designs, Cases 19, 20, and 21, have replaced this design for shorter spans.

Cases 16 and 17 are similar to Cases 1 and 2, except that they flare the rail and terminal as far from the road as possible and reduce the length of need.

Case 18 is used on the trailing end of bridge rail on a one-way roadway. No transition is necessary.

Cases 19 (A and B) are used where it is not possible to install a post at the 6.25 ft spacing. These designs omit one post (which results in a span of 11.5 ft which is consistent with a post spacing of 12.5 ft) and use nested W-beam to stiffen the rail. The cases differ by the location of the splice. No cutting of the rail or offsetting of the splices is necessary or desirable.

Case 20 is similar to Cases 19A and B, except that it allows for two posts to be omitted (which results in a span consistent with a post spacing of 18.75 ft).

Case 21 has a similar intent as Cases 19A, 19B, and 20 in that it allows for the omission of posts to span an obstruction. This design uses CRT posts with additional post blocks for three posts before and after the omitted posts. The design allows for 3 posts to be omitted (which results in a span consistent with a post spacing of 25 ft).

Case 22 is the Strong Post Intersection Design that provides a stiff barrier. This design is only to be used as a last resort at crossroads or road approaches where a barrier is necessary and there isn’t a clear area behind the nose or minimum distances for a “Weak Post Intersection Design.” (See Cases 12 and 13.)

710.07 Cable Barrier

Cable barrier is a flexible barrier system that can be used on a roadside or as a median barrier.

This system consists of three steel cables mounted to steel posts (weak posts). The maximum spacing for the steel posts is 16 ft on tangent sections and curves of 700 ft radius or greater. A deflection of 11.5 ft is anticipated with this post spacing. A smaller spacing is required on radii less than 700 ft. For tangent sections and large radius curves, the deflection can be reduced to 7 ft by reducing the post spacing to 4 ft.

At each end of the barrier run, the cable is turned down and anchored to concrete blocks. A coil spring and turnbuckle are required on each cable to maintain tension on the system.

Cable barrier can be installed up to one foot in front of side slopes as steep as 2H:1V. This barrier is the only barrier that can be placed on a side slope steeper than 10H:1V within the 12 ft area immediately beyond the breakpoint. Do not place this barrier on a side slope steeper than 6H:1V. Figure 710-14 shows the placement of cable barrier.

When cable barrier is to be connected to a more rigid barrier, a transition section is required. Contact the HQ Design Office for details.

The primary advantage of cable barrier is that it provides effective vehicle containment and redirection while imposing the lowest deceleration forces on the vehicle's occupants. It also has advantages in heavy snowfall areas and it does not present a visual barrier, which may make it desirable on Scenic Byways. (See 710.05.)

Maintenance is a consideration because routine maintenance is necessary to keep tension in the cables and a comparatively long run of cable barrier will have to be repaired after an impact. However, the effort (time and materials) required to maintain and repair cable barrier is much less than the effort required for a W-beam system.

710.08 Concrete Barrier

Concrete barriers are rigid or unrestrained rigid systems. They are also used as shoulder barriers. These systems are stiffer than beam or cable barrier and impacts with these barriers will tend to be more severe.

Light standards mounted on top of concrete median barrier must not have breakaway features. See the Standard Plans for the concrete barrier light standard section.

Where drainage might be a problem, contact the HQ Hydraulics Branch for guidance.

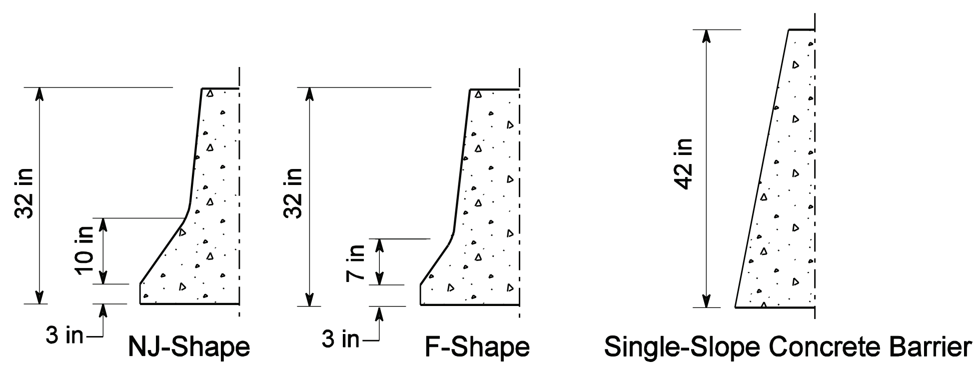
(1) Concrete Barrier Shapes

Concrete barriers use a safety shaped (New Jersey shape and, on bridges, the F-Shape) or single-sloped face to redirect vehicles while minimizing vehicle vaulting, rolling, and snagging. A comparison of these barrier shapes is shown on Figure 710-7.

The New Jersey shaped face is used on precast concrete barrier.

The single-slope barrier face is recommended when separating roadways with different elevations (stepped medians). The single-slope barrier face can be used for bridge rails (median or outside) when it is to be used on any approach to a bridge and an existing bridge rail is to be replaced.

The F-Shape face is used on all other bridge rails and on cast-in-place barrier where the New Jersey and single-slope face are not appropriate. When the F-Shape face is used and precast barrier is to be used on the approaches, a cast-in-place transition section is required so that no vertical edges of the barriers are exposed to oncoming traffic. For details on the F-Shape barrier or any of the bridge rail designs, see the *Bridge Design Manual*.



Concrete Barrier Shapes
Figure 710-7

For aesthetic reasons, avoid changes in the shape of the barrier face within a project or corridor.

(a) **New Jersey Shape Barrier.** The New Jersey shaped face is primarily used on precast concrete barrier.

Concrete barrier Type 2 (see the Standard Plans) is a precast barrier that has the New Jersey shape on two sides and can be used for both median and shoulder installations. This barrier is 32 in in height, which includes 3 in for future pavement overlay.

The cost of precast Type 2 barrier is significantly less than the cost of the cast-in-place barriers. Therefore, consider the length of the barrier run to determine whether transitioning to precast Type 2 barrier is desirable. If precast Type 2 barrier is used for the majority of a project, use the New Jersey face for small sections that require cast-in-place barrier, such as for a light standard section.

Concrete barrier Type 4 is also a precast, single-faced New Jersey shaped barrier. These units are not freestanding and must be placed against a rigid structure or anchored to the pavement. If Type 4 barriers are used back to back, consider filling any gap between them to prevent tipping.

Concrete barrier Type 5 is a precast barrier that has a single New Jersey face and is intended for use at bridge ends where the flat side is highly visible. Both Type 2 and Type 5 designs are freestanding, unanchored units connected with steel pins through wire rope loops. For permanent installation, this barrier is placed on a paved surface and a 2 ft wide paved surface is provided beyond the barrier for its displacement during impact. (See Chapter 640.)

Precast barrier can be anchored where a more rigid barrier is desired. Anchoring methods are shown in the Standard Plans. The Type 1 and 2 anchors are for temporary installations on a rigid pavement. Type 3 anchors can be used in temporary or permanent installations on an asphalt pavement. Consult the Bridge and Structures Office for details when anchoring permanent precast concrete barrier to a rigid pavement.

Precast barrier used on the approach to bridge rail must be connected to the bridge rail by installing wire rope loops embedded 15 in into the bridge rail with epoxy resin.

For unrestrained (unanchored) precast concrete barrier, the preferred foundation slope is 5 percent or flatter with a maximum of 8 percent. Keep the slope of the area between the edge of the shoulder and the face of the traffic barrier as flat as possible. The maximum slope is 10H:1V (10 percent).

(b) **Single Slope Barrier.** The single slope concrete barrier can be cast-in-place, slipformed, or precast. The most common construction technique for this barrier has been slipforming but some precast single slope barrier has been installed. The primary benefit of using precast barrier is that it can be used as temporary barrier during construction and then reset into a permanent location.

This barrier is considered a rigid system regardless of the construction method used. For new installations, the minimum height of the barrier above the roadway is 34 in which allows 2 in for future overlays. The minimum total height of the barrier section is 42 in with a minimum of 3 in embedded in the roadway wearing surface. This allows for use of the barrier between roadways with grade separations of up to 5 in. For greater grade separations, the barrier must have a depth of embedment equal to or greater than the grade separation or have an equivalent structural foundation. Contact Bridge and Structures for barrier heights over 54 in. (See the Standard Plans.)

(2) Concrete Barrier Terminals

Whenever possible, bury the end of the concrete barrier in the backslope. The backslope required to bury the end must be 3H:1V or steeper and at least 4 ft in height above the roadway. Flare the concrete barrier into the backslope using a flare rate that meets the criteria in 710.05(3). Provide a 10H:1V or flatter foreslope into the face of the barrier and maintain the full barrier height to the foreslope/backslope intersection. This might require filling ditches and installing culverts in front of the barrier face.

A precast or cast-in-place terminal section having a minimum length of 48 ft and a maximum length of 80 ft is another end treatment. It can only be used for posted speeds of 35 mph or less. Contact the HQ Design Office for details on this end treatment.

The 7 ft long precast concrete terminal end section for Concrete Barrier Type 2 may be used:

- Outside the Design Clear Zone.
- On the trailing end of the barrier when it is outside the Design Clear Zone for opposing traffic.
- On the trailing end of one-way traffic.
- Where the posted speed is 25 mph or less.

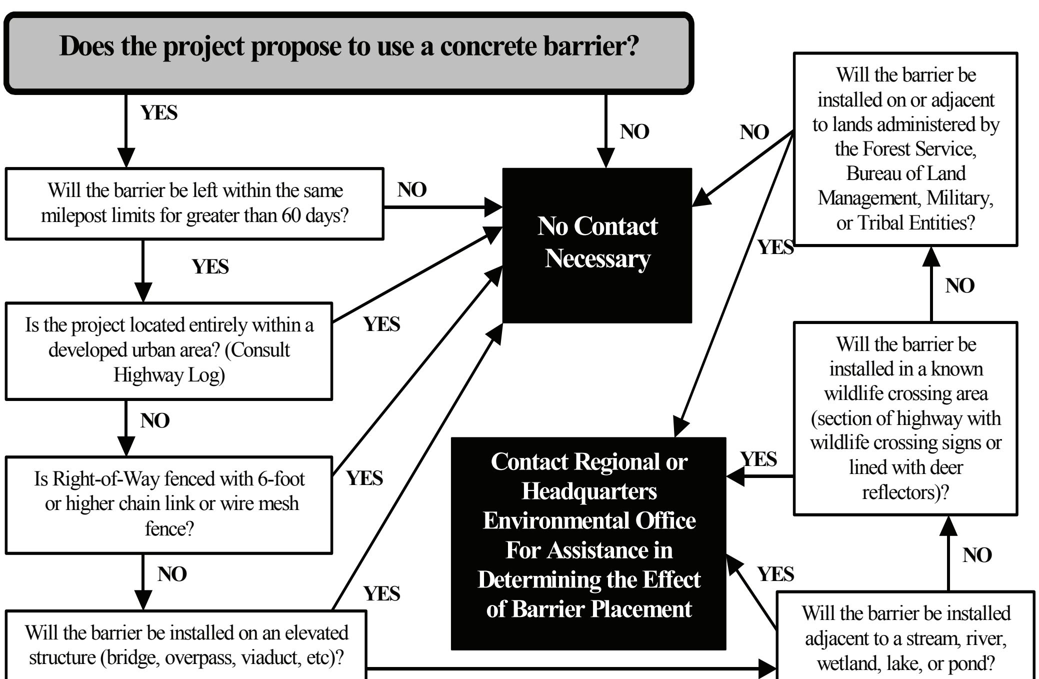
When the Barrier Terminals and Transitions column of a design matrix applies to a project, existing sloped down concrete terminals that are within the Design Clear Zone must be replaced when they do not meet the criteria above.

When the end of a concrete barrier cannot be buried in a backslope or terminated as described above, terminate the barrier using a guardrail terminal and transition or an impact attenuator. (See Chapter 720.)

(3) Assessing Impacts to Wildlife

The placement of concrete barriers in locations where wildlife frequently cross the highway can influence traffic safety and wildlife mortality. When wildlife encounter physical barriers that are difficult for them to cross, they often travel parallel to those barriers. With traffic barriers, this means that they often remain on the highway for a longer period, increasing the risk of wildlife/vehicle collisions or vehicle/vehicle collisions as motorists attempt avoidance.

Traffic-related wildlife mortality may play a role in the decline of some species listed under the Endangered Species Act. To address public safety and wildlife concerns, see Figure 710-8 to determine if concrete barrier placement requires an evaluation by the Environmental Office to determine its effect on wildlife. Make this evaluation early in the project development process to allow adequate time for discussion of options.



Concrete Barrier Placement Guidance
Figure 710-8

710.09 Special Use Barriers

The following barriers may be used on designated Scenic Byway and Heritage Tour routes if funding can be arranged. (See 710.05 and Chapter 120.)

(1) Steel Backed Timber Guardrail

Steel backed timber guardrails consist of a timber rail with a steel plate attached to the back to increase it's tensile strength. There are several variations of this system that have passed crash tests. The nonproprietary systems use a beam with a rectangular cross section that is supported by either wood or steel posts. A proprietary (patented) system called the Ironwood guardrail is also available. This system uses a beam with a round cross section and is supported by steel posts with a wood covering to give the appearance of an all-wood system from the roadway. The Ironwood guardrail can be allowed as an alternate to the nonproprietary system. However, specifying this system exclusively requires the approval, from the Assistant State Design Engineer, of a public interest finding for the use of a sole source proprietary item.

The most desirable method of terminating the steel backed timber guardrail is to bury the end in a back slope as described in 710.06(2). When this type of terminal is not possible, the use of the barrier is limited to highways with speeds of 45 mph or less. On these lower speed highways, the barriers can be flared away from the traveled way and terminated in a berm.

For details of these systems, contact the HQ Design Office.

(2) Stone Guardwalls

Stone guardwalls function like rigid concrete barriers but have an appearance of natural stone. These walls can be constructed of stone masonry over a reinforced concrete core wall or of simulated stone concrete. These types of barriers are designed to have a limited projection of the stones that will not affect the redirectional characteristics of the barrier. The most desirable method of terminating this barrier is to bury the end in a backslope as described in 710.08(2). When this type of terminal is not possible, the use of the barrier is limited to highways with posted speeds of 45 mph or less. On these lower speed highways, the barrier can be flared away from the traveled way and terminated in a berm.

For details of these systems, contact the HQ Design Office.

710.10 Bridge Rails

Bridge rails are traffic barriers that redirect errant vehicles and prevent them from going over the side of the structure. See the *Bridge Design Manual* for information on bridge rail on new bridges and replacement bridge rail on existing bridges.

For most new bridge rail installations, use a 32 in high safety shape (F Shape) bridge rail. The single slope bridge rail that is 34 in high can be used to be consistent with the heights of connecting single slope barrier (710.08(1)(b)).

Use taller, 42 in, safety shape or single slope bridge rails on Interstate or freeway routes where accident history suggests a need or where roadway geometrics increase the possibility of larger trucks hitting the barrier at a high angle (such as on ramps for freeway to freeway connections with sharp curvature in the alignment).

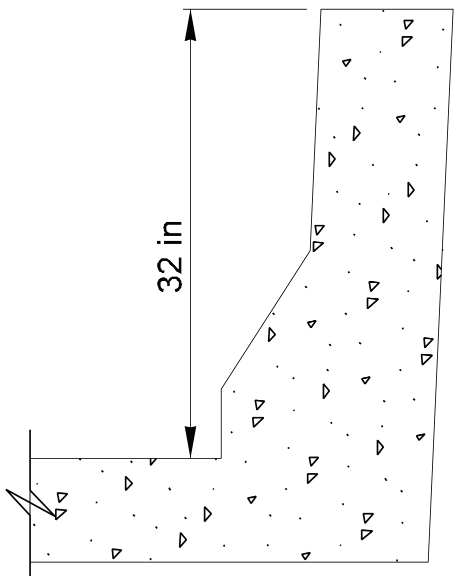
For bridges where high volumes of pedestrian traffic are anticipated, see Chapter 1020 for further guidance.

Approach barriers, transitions, and connections are usually required on all four corners of bridges carrying two-way traffic and on both corners of the approach end for one-way traffic. See 710.06(3) for guidance on transitions.

If the bridge rail system does not meet the criteria for strength and geometrics, modifications to improve its redirectional characteristics and its strength may be required. The modifications can be made using one of the retrofit methods described below.

(1) Concrete Safety Shape

Retrofitting with a new concrete bridge rail (see Figure 710-9) is costly and requires justification when no widening is proposed. Consult the Bridge and Structures Office for design details and to determine if the existing bridge deck and other superstructure elements are of sufficient strength to accommodate this bridge rail system.



Safety Shaped Concrete Bridge Rail Retrofit
Figure 710-9

(2) Thrie Beam Retrofit

Retrofitting with thrie beam is an economical way to improve the strength and redirectional performance of bridge rails. The thrie beam can be mounted to steel posts or the existing bridge rail, depending on the structural adequacy of the bridge deck, the existing bridge rail type, the width of curb (if any), and the curb-to-curb roadway width carried across the structure.

The Bridge and Structures Office is responsible for the design of thrie beam bridge rail. A key concern is that the existing bridge deck has adequate strength to withstand an impact without causing significant damage to the deck. Contact the Bridge and Structures Office for assistance with thrie beam retrofit design.

Consider the Service Level 1 (SL-1) system on bridges with wooden decks and for bridges with concrete decks that do not have adequate strength to accommodate the thrie beam system. Contact the Bridge and Structures Office for information required for the design of the SL-1 system.

Figure 710-15 shows typical installation criteria.

Many bridge rail retrofit projects involve bridges over 250 feet in length. These projects will normally be funded from the I2 program. Shorter bridges may be funded as a spot safety improvement. Contact HQ Project Control and Reporting for clarification.

710.11 Other Barriers

(1) Dragnet

The Dragnet Vehicle Arresting Barrier consists of chain link or fiber net that is attached to energy absorbing units. When a vehicle hits the system, the Dragnet brings the vehicle to a controlled stop with a minimum of damage. Possible uses for this device are as follows:

- Reversible lane entrances and exits.
- Railroad crossings.
- Truck escape ramps (instead of arrester beds – Chapter 1010).
- T-intersections.
- Work zones.

For permanent installations, this system can be installed between towers that lower the unit into position when needed and lift it out of the way when it is no longer needed. For work zone applications, it is critical to provide deflection space for stopping the vehicle between the system and the work zone. For additional information on the Dragnet, contact the HQ Design Office.

710.12 Documentation

A list of documents that are to be preserved [in the Design Documentation Package (DDP) or the Project File (PF)] is on the following website: http://www.wsdot.wa.gov/eesc/design/projectdev/

Connecting W-Beam Guardrail to: Transitions and Connections			Transition Type*	Connection
Bridge Rail	New		1[1] 4[5]	D
	Existing Concrete Parapet	> 20 inches	1[1] 4[5]	Figure 710-6
		< 20 inches	2 4[5]	Figure 710-6
		Existing W-Beam Transition	2[2][6] 4[5]	(2)
	Thrie Beam at face of curb[4]	Approach end	10	na
		Trailing end (two way traffic only)	11 12	na
	Thrie Beam at bridge rail (curb exposed) [4]	Approach end	13	na
		Trailing end (two way traffic only)	14 15	na
	Weak Post Intersection Design (see 710.06(4) cases 12 & 13)		5	Figure 710-6
Concrete Barrier	Rigid/ Restrained		1 4[5]	Figure 710-6
	Unrestrained		2 4 [5]	A
Weak Post Barrier Systems (Type 20 and 21)			6	na
Rigid Structures such as Bridge Piers	New installation(see Case 11)		16 17 18	na
	Existing W-Beam Transition		(3)	na
Connecting Thrie Beam Guardrail to:				
Bridge Rail or Concrete Barrier	New installation (example - when used with thrie beam bull nose)		1B	Figure 710-6

*Consult section C of the Standard Plans for detail on transition types.

(1) A Type 1A transition can be used where there is a problem placing a post within 2'-5" from the end of the bridge in which case a B or E connection is required. When the E connection is to be used, a special detail for the end of the bridge is required. Contact the HQ Bridge and Structures Office.

(2) If work requires reconstruction or resetting of the transition, upgrade as shown above. Raising the guardrail is not considered reconstruction. If the transition is not being reconstructed, the existing connection may remain in place. See 710.06(2)(d) for guidance when Type 3 anchors are encountered.

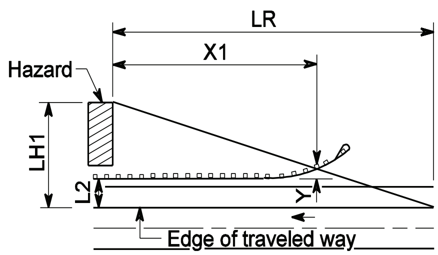
(3) For new/reconstruction, use Case 11 (thrie beam). For existing Case 11 with W-beam, add (nest) a second W- beam rail element.

(4) For Service Level 1 bridge rail see 710.06(4), case 14.

(5) Use on highways with speeds 45 MPH or less.

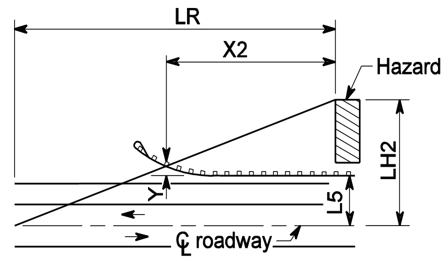
(6) If existing transition has adequate guardrail height, three 10"x10" (nominal) posts and three 6"x8" (nominal) posts spaced 3'-1.5" apart, it is acceptable to nest existing single W-beam element transitions.

Transitions and Connections
Figure 710-10



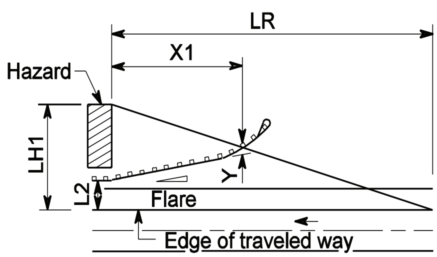
$$X1 = \frac{LH1 - (L2+Y)}{(LH1/LR)}$$

Adjacent-Side Hazard
Barrier Parallel to Roadway



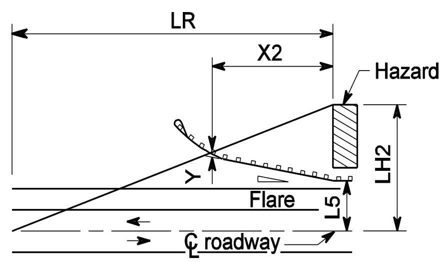
$$X2 = \frac{LH2 - (L5+Y)}{(LH2/LR)}$$

Opposite-Side Hazard
Barrier Parallel to Roadway



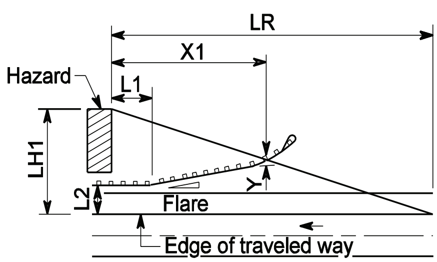
$$X1 = \frac{LH1 - (L2+Y)}{(1/F) + (LH1/LR)}$$

Adjacent-Side Hazard
Barrier Flare Begins at Hazard



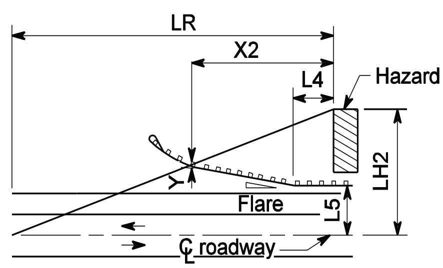
$$X2 = \frac{LH2 - (L5+Y)}{(1/F) + (LH2/LR)}$$

Opposite-Side Hazard
Barrier Flare Begins at Hazard



$$X1 = \frac{(LH1 + L1/F) - (L2+Y)}{(1/F) + (LH1/LR)}$$

Adjacent-Side Hazard
Barrier Flare Begins Before Hazard



$$X2 = \frac{(LH2 + L4/F) - (L5+Y)}{(1/F) + (LH2/LR)}$$

Opposite-Side Hazard
BarrierFlare Begins Before Hazard

Barrier Length of Need
Figure 710-11a

L1 = Length of barrier parallel to roadway from adjacent-side hazard to beginning of barrier flare. This is used if a portion of the barrier cannot be flared (such as a bridge rail and the transition).

L2 = Distance from adjacent edge of traveled way to portion of barrier parallel to roadway.

L4 = Length of barrier parallel to roadway from opposite-side hazard to beginning of barrier flare.

L5 = Distance from center line of roadway to portion of barrier parallel to roadway. Note: if the hazard is outside of the Design Clear Zone when measured from the center line, it may only be necessary to provide a crashworthy end treatment for the barrier.

LH1 = Distance from outside edge of traveled way to back side of adjacent-side hazard. Note: if a hazard extends past the Design Clear Zone, the Design Clear Zone can be used as LH1.

LH2 = Distance from center line of roadway to back side of opposite-side hazard. Note: if a hazard extends past the Design Clear Zone, the Design Clear Zone can be used as LH2.

LR = Runout length (measured parallel to roadway).

X1 = Length of need for barrier to shield an adjacent-side hazard.

X2 = Length of need for barrier to shield an opposite-side hazard.

F = Flare rate value.

Y = Offset distance required at the beginning of the length of need.

Different end treatments require different offsets.

For the SRT 350 and FLEAT 350, use Y = 1.8 ft.

For evaluating existing BCT's, use Y = 1.8 ft.

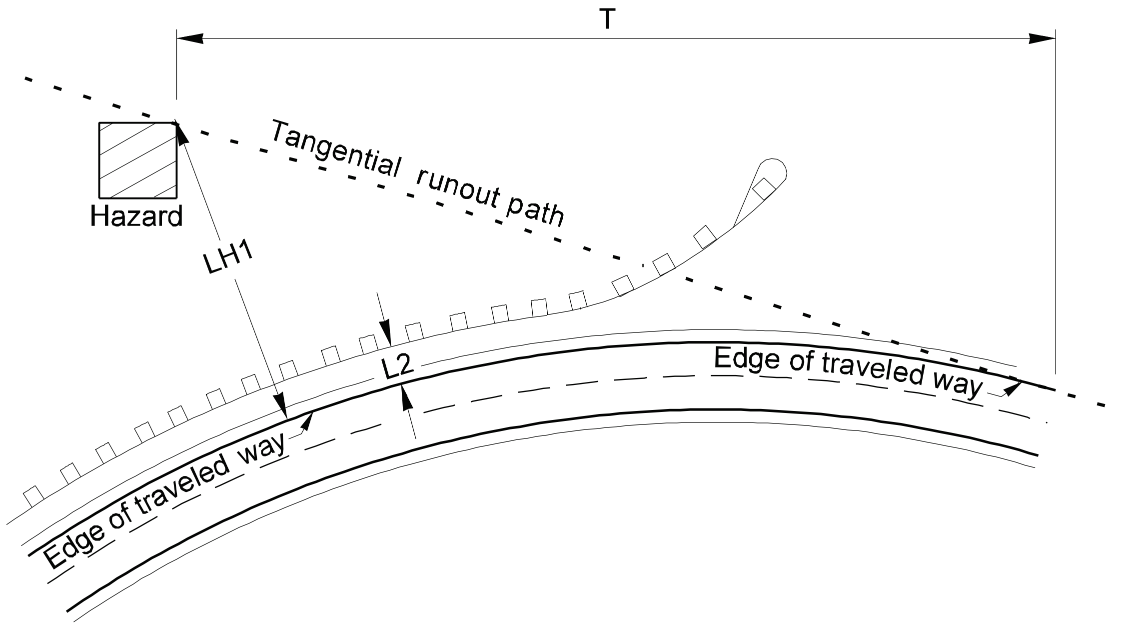
For the FLEAT TL-2, use Y = 0.8 ft.

No offset is required for the nonflared terminals, or impact attenuator systems. Use Y = 0.

Buried terminal end treatments are used with barrier flares and have no offset. Use Y = 0.

Design Parameters							
Posted Speed	ADT						
	Over 10,000	5,000 to 10,000	1,000 to 4,999	Under 1,000	Rigid Barrier	Unrestrained Barrier	Semirigid Barrier
(mph)	LR (ft)	LR (ft)	LR (ft)	LR (ft)	F	F	F
70	460	395	345	295	20	18	15
60	360	295	260	230	18	16	14
55	310	260	230	195	16	14	12
50	260	215	180	165	14	12	11
45	245	195	165	150	12	11	10
40	215	180	150	130	11	10	9

Barrier Length of Need
Figure 710-11b



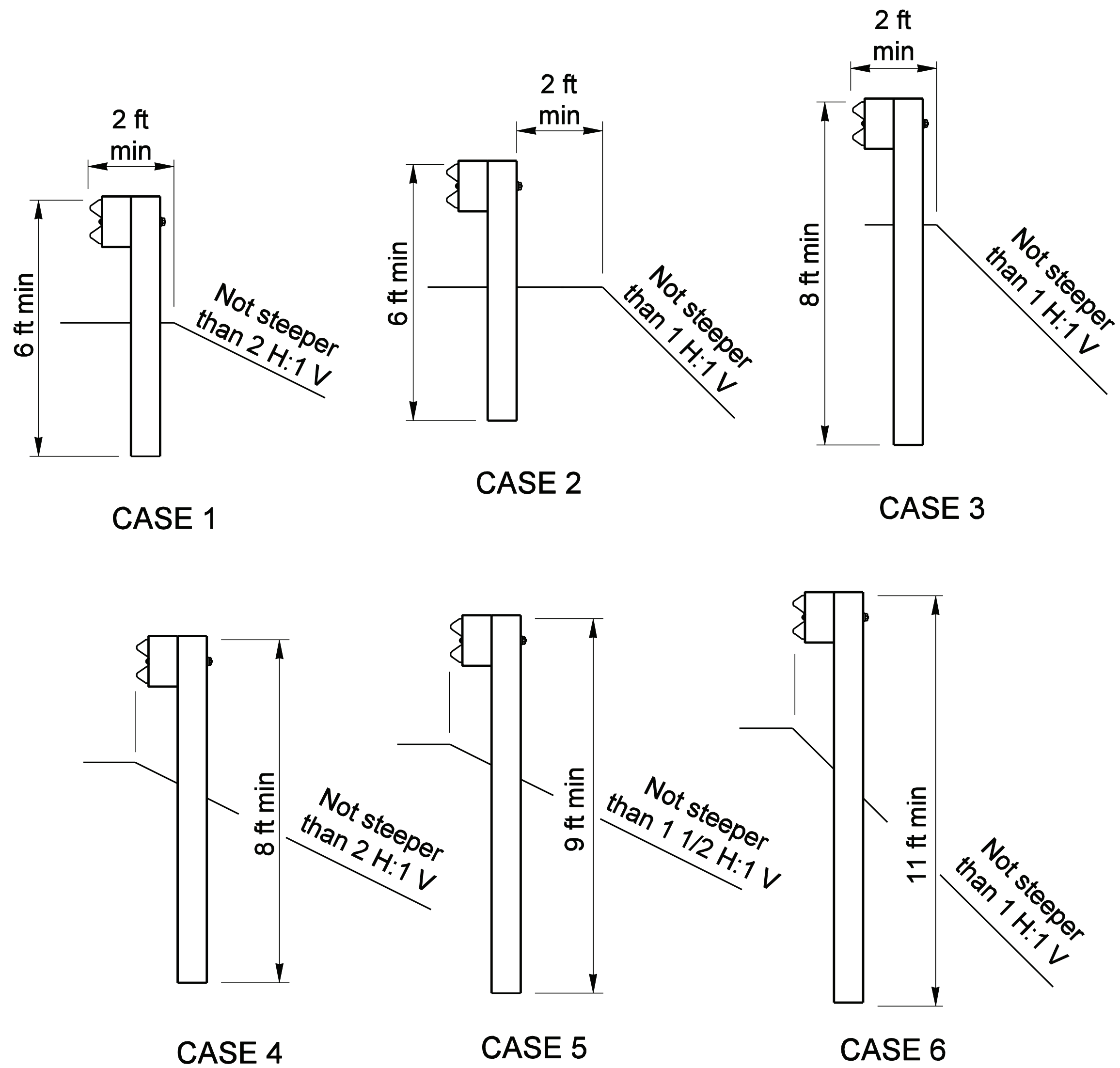
Note:

This is a graphical method for determining the length of need for barrier on the outside of a curve. On a scale drawing, draw a tangent from the curve to the back of the hazard. Compare T to LR from Figure 710-11b and use the shorter value.

If using LR, follow Figures 710-11a and b.

If using T, draw the intersecting barrier run to scale and measure the length of need.

Barrier Length of Need on Curves
Figure 710-11c

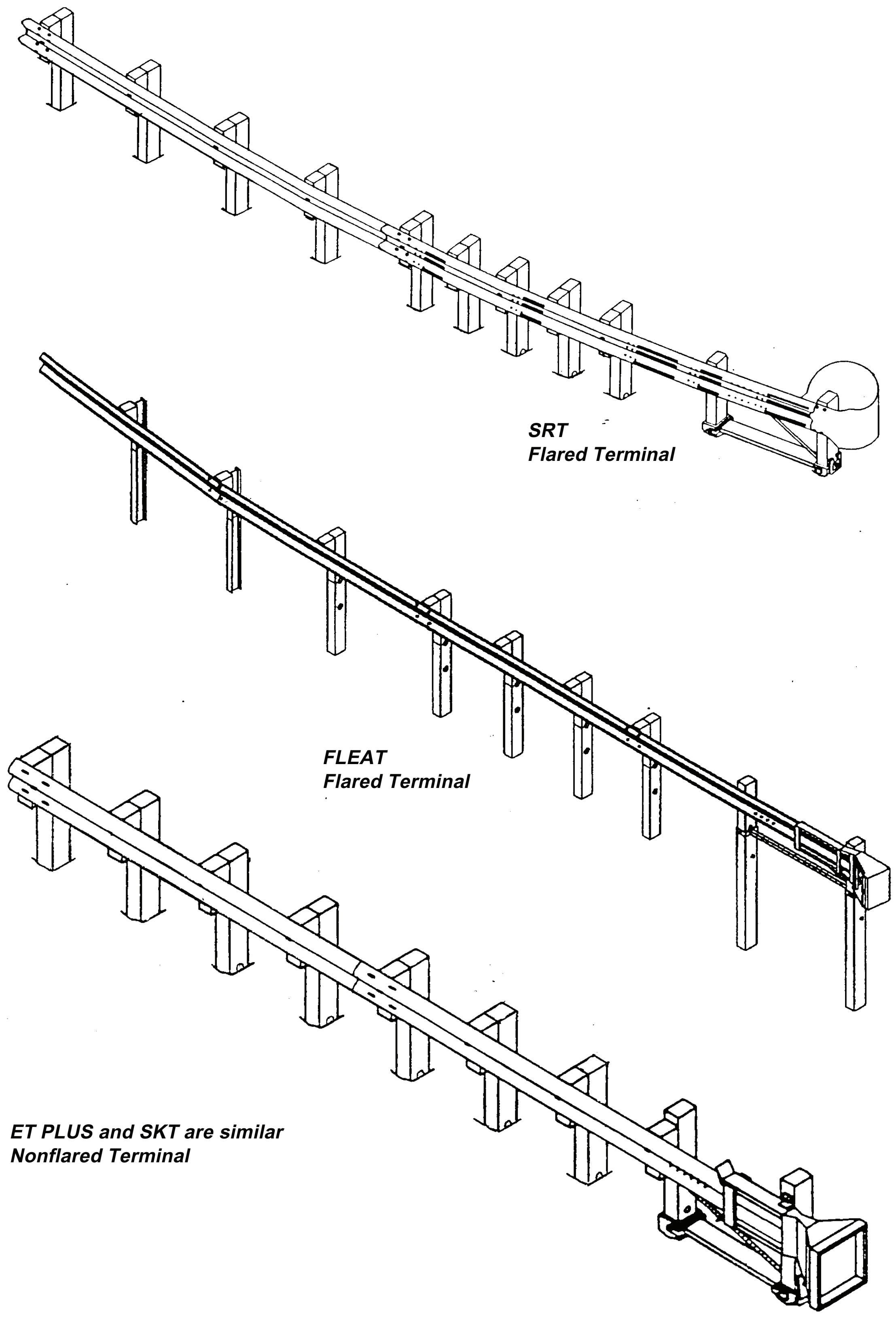


Notes:

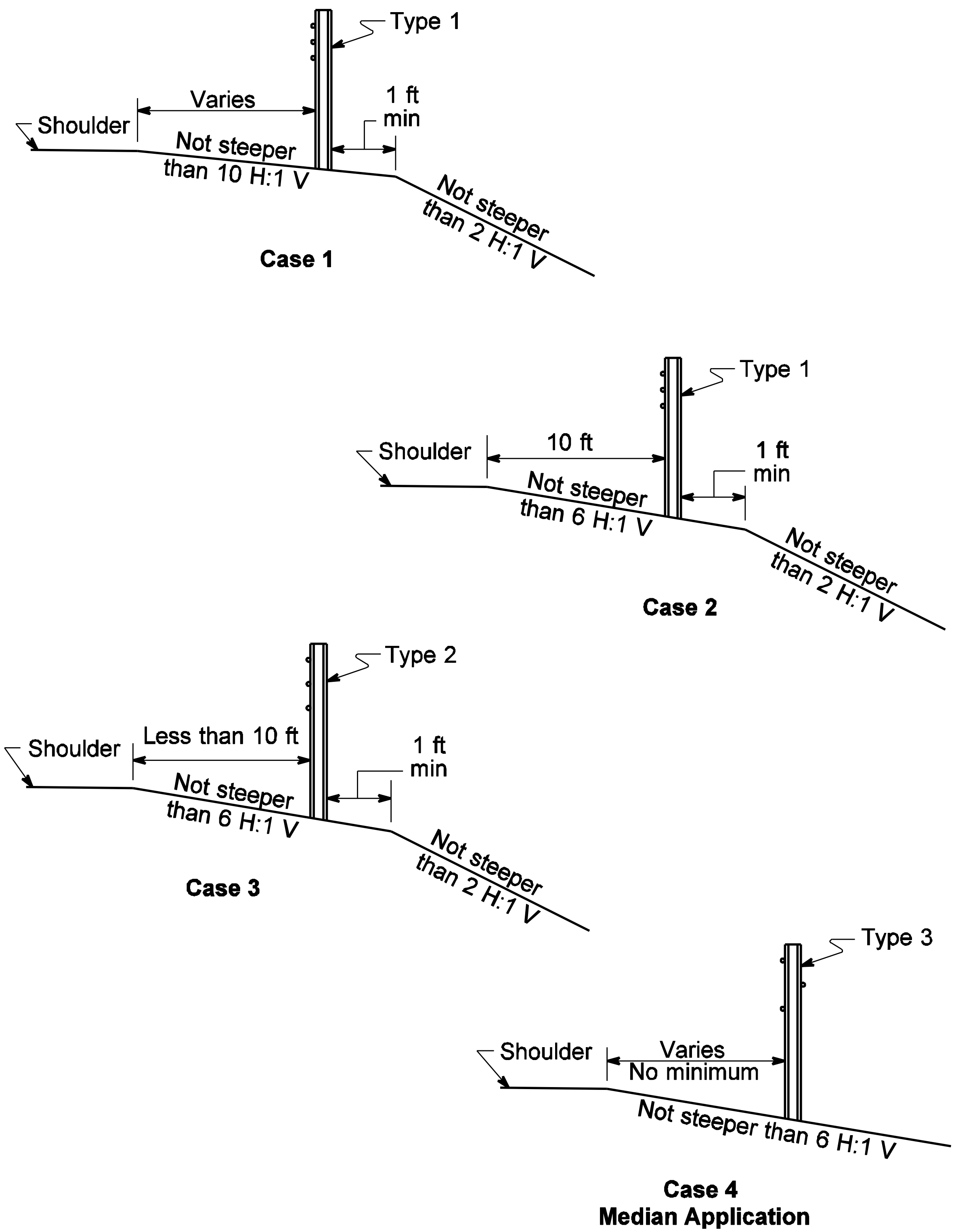
Use cases 1, 2, and 3 when there is 2 ft or greater shoulder widening from face of guardrail to the breakpoint.

Use cases 4, 5, and 6 when there is less than 2 ft shoulder widening from face of guardrail to the breakpoint.

Beam Guardrail Post Installation
Figure 710-12



Beam Guardrail Terminals
Figure 710-13

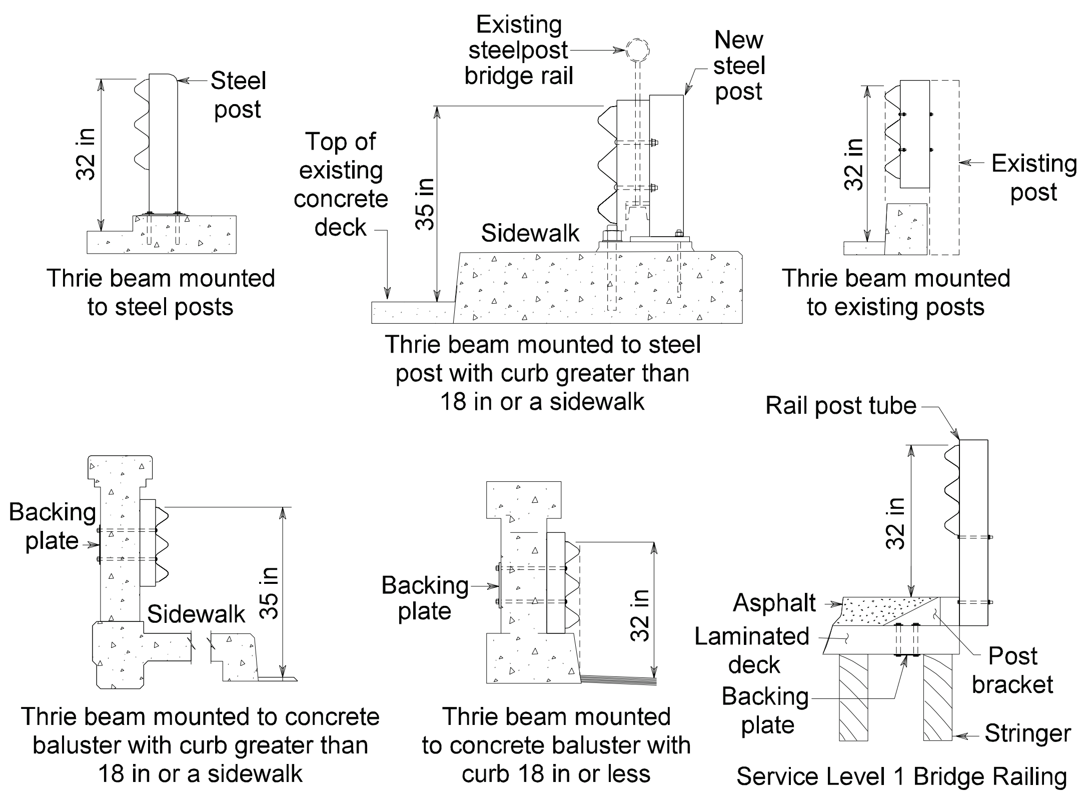


Cable Barrier Locations on Slopes
Figure 710-14

		Concrete Bridge Deck		Wood Bridge Deck or Low Strength Concrete Deck
Curb Width	**Bridge Width**	**Concrete Bridge Rail (existing)**	**Steel or Wood Post Bridge Rail (existing)**	
< 18 in		Thrie beam mounted to existing bridge rail[2] and blocked out to the face of curb. Height = 32 in	Thrie beam mounted to steel posts[2] at the face of curb. Height = 32 in	Service Level 1 Bridge Rail[2]
> 18 in	**> 28 ft (curb to curb)**	Thrie beam mounted to steel posts[2] at the face of curb[1]. Height = 32 in		Height = 32 in
> 18 in	**< = 28 ft (curb to curb)**	Thrie beam mounted to existing bridge rail[2]. Height = 35 in	Thrie beam mounted to steel posts[2] in line with existing rail. Height = 35 in	Curb or wheel guard must be removed

(1) Thrie beam may be mounted to the bridge rail to accommodate pedestrians (height = 35 in).

(2) Contact the Bridge and Structures Office for design details on bridge rail retrofit projects.



Thrie Beam Bridge Rail Retrofit Criteria

Figure 710-15